CANDIDATE AND LISTING PRIORITY ASSIGNMENT FORM

SCIENTIFIC NAME: *Phaeogramma* sp.

COMMON NAME: Poolanui gall fly

LEAD REGION: Region 1

INFORMATION CURRENT AS OF: February 2002

STATUS/ACTION (Check all that apply):
___ New candidate
 X Continuing candidate
    X Non-petitioned
    ___ Petitioned - Date petition received: ___
        ___ 90-day positive - FR date: ___
        ___ 12-month warranted but precluded - FR date: ___
______________ Is the petition requesting a reclassification of a listed species?
    ___ Listing priority change
        Former LP: ___
        New LP: ___
___ Candidate removal: Former LP: ___ (Check only one reason)
    ___ A - Taxon more abundant or widespread than previously believed or not subject to a degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status.
    ___ F - Range is no longer a U.S. territory.
    ___ M - Taxon mistakenly included in past notice of review.
    ___ N - Taxon may not meet the Act's definition of "species."
    ___ X - Taxon believed to be extinct.

ANIMAL/PLANT GROUP AND FAMILY: Tephritidae (Fruit Fly)

HISTORICAL STATES/TERRITORIES/COUNTRIES OF OCCURRENCE: Hawaii, island of Kauai

CURRENT STATES/TERRITORIES/COUNTRIES OF OCCURRENCE: Hawaii, island of Kauai

LEAD REGION CONTACT (Name, phone number): Wendi Weber (503/231-6131)

LEAD FIELD OFFICE CONTACT (Office, name, phone number): Pacific Islands Office, Mike Richardson (808/541-3441)

BIOLOGICAL INFORMATION (Describe habitat, historic vs. current range, historic vs. current population estimates (# populations, #individuals/population), etc.):

Although flies in the family Tephritidae are most commonly thought of as agricultural pests (fruit flies), the Hawaiian Islands have at least 26 endemic species. The larvae of species in the genus *Trupanea* Schrank typically develop in the flower heads of native Asteraceae such as *Dubautia*, *Argyroxyphium*, *Artemisia,* and *Bidens* (Hardy and Delfinado 1980). At least one species of Hawaiian *Trupanea*, *T. celaenoptera* Hardy, forms stems galls on *Dubautia* at Pohakuloa on Hawaiʻi island, and a closely related species from Hualalai, *T. nigripennis* Hardy, may also be a gall-former. The endemic Hawaiian genus *Phaeogramma* Grimshaw was erected to contain species with unusual striped wing markings (Grimshaw 1901). All species of *Phaeogramma* also form stem galls on Hawaiian species of *Bidens* (Asteraceae). To date, two species of *Phaeogramma* have been described, *Phaeogramma hispida* Hardy from Maui, and *P. vittipennis* Grimshaw from Molokaʻi. Hardy and Delfinado (1980) tentatively included a series of specimens from Oahu's Waianae Mountains as *P. hispida*, and Swezey (1954) reported pupae that may have been these flies from Kauai. In 1991, Asquith *et al*. (1995) confirmed the presence of an additional, undescribed species of *Phaeogramma* on Kauai.

The galls of this species develop in the internodes along the distal 0.5 meters (m) (1.6 feet (ft)) of stems and occasionally branches of its host plant. Gall development has not been examined, but only a single larva or pupa are found in each mature gall. Mature, third instar larva develop in an elongate oval feeding chamber only slightly larger than the larva itself. The longitudinal axis of the larva is oriented with the long axis of the stem or branch. Prior to pupation, the larva extends the feeding chamber for a short distance apically and then laterally to form an exit tunnel. A thin cuticular window is left at the end of the exit tunnel and the larva returns to the base of the feeding chamber to pupate. The general structure of these galls and behavior of the larvae (Asquith *et al*. 1995) are similar that described for other gallicolous Tephritidae (Goeden 1990a, b; Goeden and Headrick 1991).

Phenology of adult emergence in the field has not been determined. Despite the fact the malaise traps were positioned in stands with galls, only two flies were caught in an entire 2 year period (Asquith *et al*. 1995). One individual was trapped in April and the other in August. This low incidence of capture underscores the rarity of this fly. For example, *Trupanea bidensicola* Hardy, is also endemic to Kauai and develops only in the flower heads of *Bidens cosmoides*. During the same trapping period, however, over 300 individuals of *T. bidensicola* were captured in the malaise traps.

With one exception, galls are found only in plants of *Bidens cosmoides*. In the Wahiawa Mountains, galls were found in both *B. cosmoides* and *B. forbesii* or a *B. cosmoides* x *B. forbesii* hybrid (D. Lawrence, National Tropical Botanical Gardens, pers. comm., 1996). *Bidens cosmoides* is a mesic forest species, and is usually found under a canopy of *Metrosideros polymorpha* or *Acacia koa*, with an an understory of *Melicope* spp. or *Coprosma* sp. The ground cover in this habitat is typically *Rubus* sp., or ferns. Herbarium specimen data indicate that *B. cosmoides* will also grow in wetter habitat, such as Kilohana Lookout on the edge of Wainiha Valley, but plants are extremely rare in these areas and never support galls.

Galls are found most abundantly in the narrow strip of mesic forest at the head and eastern ridges of Waimea Canyon between 1,060-1,160 m (3,477-3,805 ft) elevation. Galls are also found on Kumuwela Ridge, Kohua Ridge, Nawaimaka Ridge, Kapukapaia Ridge and the heads of some valleys between these ridges. A small, single patch of galls were also found at 1,250 m (4,100 ft) in Kaahuamaa Flats, but galls are not found on *B. cosmoides* on the west slopes of Kokee or along the west rim of Waimea Canyon. The occurrence of galls in the Wahiawa Mountians, suggests that the fly probably also occurs on the ridges between Kapukapaia and Wahiawa such as Kalaukea Ridge, Nakanukalolo Ridge, Ohulelua Ridge, and the ridges of the Olokele and Hanapepe river drainages. This land is privately owned and has not been surveyed.

Thirty different stands of the host plant *Bidens cosmoides* have been surveyed. Over 4,400 plants have been examined and 740 galls observed. Galls occur in 20, or two thirds of the stands surveyed. The absolute number of galls in a stand is not related to number of plants in the stand, the amount of shade, or the slope. *Phaeogramma* does not appear to be strictly limited by the number of available plants, thus the average number of galls per plant rather than total number of galls is used as a measure of stand suitability. The average number of galls per plant in a stand ranges from 6 galls / 1000 plants to 4.5 galls / plant. In only three stands is the average greater than one gall per plant. There is a slight negative correlation between the percent shade and number of galls per plant, suggesting that flies select or do better in stands with more sunlight. There is also a slight negative correlation between the number of plants in a stand and the number of galls per plant, again indicating that females do not utilize all available plants in a stand, and plants can and frequently do support more than one gall.

Strong evidence for the effect of stand/plant condition on gall formation comes from the pre- and post hurricane (1992) surveys. A total of 72 galls were observed in a stand before the hurricane. In the survey after the hurricane, 438 galls were counted. Seventy six of these were old galls, which corresponded closely with the total number observed before the hurricane. Over 360 galls developed the year following the hurricane. This explosion in gall development corresponded to an obvious flush in growth of the *Bidens* plants. This growth flush probably resulted from the increased sunlight reaching the understory from the canopy that had been opened by the hurricane. This suggests that galls develop more successfully in plants undergoing rapid growth.

Three stands have experienced extinctions (only old galls were evident) and at least two stands are recently colonized (only new galls). While the data are limited, it appears that extinction in stands is roughly equal to colonization of stands, so that the total number of occupied stands is probably stable. Total emergence from old galls (77) was similar to the total emergence from new galls (80), again suggesting a stable population (flies had not yet emerged from post-hurricane survey stand).

Old galls show 50 oercent successful emergence, with 25 percent parasitized, and another 25 percent with unexplained mortality (no emergence). This is a minimum estimate of parasitization because it is based on successful emergence of the parasitoid. Significant mortality can result without parasitoid emergence (T. Duan, pers. comm., 1996), thus a large part of the unexplained mortality may also be due to parasitoids.

Of new galls, 20 percent are parasitized and 13 percent emerged. If new galls eventually have the same emergence success of old galls, we estimate an emergence of approximately 150 adults from new galls surveyed (post hurricane survey data from stand #7 were excluded from this estimate, approximately 150 adults would have emerged from that stand alone following the hurricane).

Successful emergence is positively related to stand size (number of plants in stand). Stands with more than 40 plants have significantly higher emergence success (percent emergence) from old galls than stands with less than 40 plants. Successful emergence is also positively related to population size (number of galls in stand). Stands with six or more old galls have significantlly greater emergence success from those galls than stands with less than six old galls, and there was no successful emergence from any stands with less than five galls. A similar disparity in emergence success is evident when all galls are used to assess population size.

While available surveys provide relative rather than absolute data on the total population size of *Phaeogramma*, given the small numbers discovered, it is instructive to roughly estimate the total population size of this fly. Although we do not know for how long galls persist on the plant, flies successfully emerged from 80 old galls (50 percent emergence). Assuming the same success emergence, approximately 150 adult flies would emerge from new galls surveyed (again, eliminating the unusual post-hurricane survey of stand #7). Assuming these numbers represent annual productions, then roughly between 100 and 200 adult flies emerge annually from the stands that have been surveyed. We estimate that we have located at least half the stands in the areas surveyed, and approximately half of the potential range of *Phaeogramma* has been surveyed. Thus, a liberal estimate of the annual emergence of adult *Phaeogramma* on Kauai is between 500 and 1,000 flies. This would be an extraordinarily small total population for an insect, and for a fly in particular. Even if our estimate is off by an order of magnitude, which seems unlikely, less than 10,000 individuals comprising the entire species is remarkable. For example, the butterfly subspecies *Euphydryas editha bayensis* in the San Francisco Bay area is listed as threatened under the Endangered Species Act. However, the main core population of this taxon normally has between 10^4 to 10^5 individuals (Murphy & Weiss 1988), and local extinctions are still part of its populations dynamics (Ehrilch *et al*. 1980). Tscharntke (1992) documented the local extinction of a stem boring moth despite an original population of 180,000 adults. Tscharntke (1992) also estimated that for the gall midge, (*Giraudiella inclusa*) to avoid local extinction would require 11,000 adults or 84,000 larvae in galls.

THREATS (Describe threats in terms of the five factors in section 4 of the ESA providing specific, substantive information. **If this is a removal of a species from candidate status or a change in listing priority, explain reasons for change)**:

A. <u>The present or threatened destruction, modification, or curtailment of its habitat or range</u>.

Native vegetation on all the main Hawaiian islands has undergone extreme alteration because of past and present land management practices including ranching, deliberate introduction of alien plants and animals, and agricultural development (Cuddihy and Stone 1990). Some of the primary threats facing this species are ongoing and threatened destruction and adverse modification of habitat be feral animals and alien plants.

Animals such as pigs, goats, axis deer, black-tailed deer, and cattle were introduced either by the early Hawaiians (pigs) or more recently by European settlers (all ungulate species) for food and/or commercial ranching activities. Over the 200 years following their introduction, their numbers increased and the adverse impacts of feral ungulates on native vegetation have become increasingly apparent. Beyond the direct effect of trampling and grazing native plants, feral ungulates have contributed significantly to the heavy erosion still taking place on most of the main Hawaiian islands.

The habitat of this fly, a narrow strip of mesic forest around Waimea Canyon and southern ridges, was heavily impacted by feral cattle in the last century (Wenkam 1969), decimating understory growth and probably severely reducing the numbers of its host plant, *Bidens cosmoides*. While feral cattle have been removed from the Kokee area, goats (*Capra hircus*) are extremely abundant on the drier slopes. Most stands on exposed ridges had plants with stems that had been severely grazed by goats. Because galls develop in the terminal part of the stem or branches, these plants could not support flies.

Goats, native to the Middle East and India, were successfully introduced to the Hawaiian Islands in 1792. Feral goats now occupy a wide variety of habitats from lowland dry forests to montane grasslands on Kauai, Oahu, Molokai, Maui, and Hawaii, where they consume native vegetation, trample roots and seedlings, accelerate erosion, and promote the invasion of alien plants (Stone 1985; van Riper and van Riper 1982). Goats are significantly degrading the habitat of the Poolanui gall fly on dry slopes around Waimea Canyon. Most plants on open sunny slopes are continually cropped by goats and do not support galls (A. Asquith, pers. comm., 1996).

Sus scrofa (pigs), originally native to Europe, Africa, and Asia, were introduced to Hawaii by the Polynesian ancestors of Hawaiians, and later by western immigrants. The pigs escaped domestication and invaded primarily wet and mesic forests and grasslands of Kauai, Oahu, Molokai, Maui, and Hawaii. While foraging, pigs root and trample the forest floor, encouraging the establishment of alien plants in the newly disturbed soil. Pigs also disseminate alien plant seeds through their feces and on their bodies, accelerating the spread of alien plants through native forest (Cuddihy and Stone 1990; Stone 1985). Foote and Carson (1995) experimentally demonstrated the detrimental affects of feral pigs on Hawaiian picture-wings in wet forest habitat on the island of Hawaii which are similarly dependent on native host plants like *Phaeogramma*. Feral pigs are abundant throughout the range of *Phaeogramma* on Kauai. While pigs do not appear to directly eat the host plant *Bidens*, they have been observed to trample the trailing stems and introduce weeds such as blackberry (A. Asquith, pers. comm., 1996).

Because *Bidens cosmoides*, and most populations of *Phaeogramma*, occur most abundantly in the mesic forests around Waimaea Canyon, they have suffered heavily from human impact due to the accessibility of this area. Much of the mesic forest in Kokee has been planted in exotic trees such as *Grevillea robusta*, *Eucalyptus* spp, *Macaranga tanarius*, *Cryptomeria* sp. and *Sequoia* sp. With few exceptions, *Bidens cosmoides* is absent in the understory of these exotic plantings. In addition, many of the roads and hiking trails in Kokee are built along the

1,097-1,158 m (3,600-3,800 ft) contour where the plant and fly occur. These factors have resulted in the *B. cosmoides* being broken into an archipelago of smaller and increasingly isolated stands.

The plant that serves as breeding sites for the gall fly occurs as understory vegetation beneath the canopy of the *Metrosideros polymorpha* (‘ohi‘a) and koa trees, and is affected by competition with alien weeds. The Poolanui gall fly is threatened by loss of its host plants due to competition with one or more alien plant species. The most significant of these appear to be *Psidium cattleianum* (strawberry guava), *Clidemia hirta* (Koster's curse), *Lantana camara* (lantana), *Rubus argutus* (prickly Florida blackberry), *Passiflora mollissima* (banana poka).

Strawberry guava, an invasive shrub or small tree native to tropical America, has become naturalized on all of the main Hawaiian islands. Strawberry guava is capable of forming dense stands that exclude other plant species (Cuddihy and Stone 1990). This alien plant grows primarily in mesic and wet habitats and provides food for several alien animal species, including feral pigs and game birds, which disperse the plant's seeds through the forest (Smith 1985; Wagner *et al*. 1985). Strawberry guava is considered one of the greatest alien plant threats to Hawaii's rain forests and is known to pose a direct threat to the habitat of *Phaeogramma* on the island of Kauai. Strawberry guava is a major invader of forests in the Kokee and Wahiawa area where it often forms single-species stands.

Koster's curse, a noxious shrub native to tropical America, was first reported on Oahu in 1941. It had spread through much of the Koolau Mountains by the early 1960s, and spread to the Waianae Mountains by 1970 (Cuddihy and Stone 1990). It poses a serious threat to *Phaeogramma* in the Wahiawa Mountains by displacing the host plants.

Prickly Florida blackberry was introduced to the Hawaiian Islands in the late 1800s (Haselwood and Motter 1976). The fruit are easily spread by birds to open areas where this plant can form dense, impenetrable thickets (Smith 1985). On Kauai, the habitat of *Phaeogramma* is seriously threatened by this noxious weed (Asquith *et al.* 1995). Like *Bidens cosmoides*, *Rubus* also responds to an open canopy, but grows much faster and clearly competes with *B. cosmoides* for space and light. For example, after the hurricane, an attempt was made to resurvey a large stand with many galls. The area had suffered a large blow-down, opening up most of the stand to direct sunlight. Before the hurricane, *Rubus* had been present in the stand but localized; after the hurricane, *Rubus* had almost completely taken over the stand, covering all the *B. cosmoides* except those at the shaded periphery. In 19 of the 30 stands surveyed, *Rubus* was the dominant or co-dominant ground cover. Thus, *Rubus* and its facilitation by pigs, is clearly the most serious present threat to the maintenance of healthy *B. cosmoides* stands (Asquith *et al*. 1995).

Lantana, a native of the West Indies, became naturalized in dry to mesic forests and shrublands of the Hawaiian Islands before 1871 (Cuddihy and Stone 1990). This shrub often forms thick cover and produces chemicals that inhibit the growth of other plant species (Smith 1985). On Kauai, lantana is a major component of the vegetation around the east and west rims of Waimea Canyon and the southern ridges, and threatens the habitat and host plant of *Phaeogramma* (A. Asquith, pers. comm., 1996). It also hosts an alien gall fly with in turn serves as a reservoir for alien parasitoid wasps.

A vine in the passionflower family, banana poka was introduced to the islands in the 1920s, probably as an ornamental. This vine is extremely detrimental to certain wet forest habitats of Kauai, Maui, and Hawaii. Heavy growth of this vine can cause damage or death to the native trees by overloading branches, causing breakage, or by forming a dense canopy cover, intercepting sunlight and shading out native plants below. This weed is particularly threatening to *Phaeogramma* on Kauai becuase the fly requires flushing growth of its host plant which normally occurs in sunny areas, also favored by banana poka (Asquith *et al*. 1995).

B. <u>Overutilization for commercial, recreational, scientific, or educational purposes</u>.

Not applicable.

C. <u>Disease or predation</u>.

Over 2,500 alien arthropods are now established in Hawaii (Howarth 1990; Howarth *et al*. 1995; Nishida 1994), with a continuing establishment rate of 10-20 new species per year (Beardsley 1962, 1979). Many of these alien species have severe affects on the native Hawaiian insect fauna (Asquith 1995). Species of alien parasitic wasps pose the greatest threat to *Phaeogramma*. Hawaii has a limited number of native parasitic Hymenoptera (wasps), with none recorded to utilize Hawaiian Tephritidae as hosts. The alien parasitic eulphid wasp, *Euderus metallicus* causes 25 to 50 percent mortality of *Phaeogramma* (Asquith *et al*. 1995). It is the combination of habitat (host plant) loss and isolation and parasitization by the wasp *Euderus metallicus* that is threatening the viability of *Phaeogramma*. Smaller stands sustain higher levels of parasitization and have lower emergence success, and stands with small numbers of galls (< 6) never have successful emergence of flies. Because newly colonized stands will have small numbers of galls, these will rarely, if ever produce adult flies. Parasitization by *Euderus metallicus* largely prohibits establishment of new colonies of *Phaeogramma* and restricts viable (reproducing) colonies to large, healthy stands of *B. cosmoides*.

Most phytophagous insects and all continental gall-forming tephritid species that have been examined are attacked by multiple species of parasitoids. In contrast, *Phaeogramma* appears to have evolved without pressures from parasitoid predation, and is probably particularly susceptible to parasitoids (Howarth 1990; Howarth and Ramsay 1991). It is important to note that *Euderus metallicus* exerts inverse density-dependent mortality on *Phaeogramma* (Asquith *et al*. 1995), which is not uncommon among insects (Morrison and Strong 1980; Hassell 1982). *Euderus metallicus* is a generalist parasitoid, attacking a variety of Diptera, Lepidoptera, and Coleoptera larvae (Yoshimoto 1965). It probably has no trouble in finding other suitable hosts in the mesic forest habitat around Waimea Canyon, which may explain why high densities of galls are not exploited once they are discovered. Thus, while *E. metallicus* restricts the establishment of new populations of *Phaeogramma*, large established populations may be able to survive this predation pressure. The threat to large populations would be a parasitoid that selectively searches for gall forming insects and/or exhibits a density dependent mortality.

For example, one of the techniques that is currently being developed for pest fruit fly control in Hawaii, is the importation and mass release of parasitoids (USDA-APHIS 1992). Although these parasitoids are generally host specific, some are known to attack tephritid flies that form galls, such as *Procecidochares utilis* Stone on *Eupatorium adenophorum* (Maui Pamakani), and *Eutreta xanthochaeta* Aldrich on *Lantana camara* (Hardy and Delfinado 1980). One species of braconid, *Diachasmimorpha longicaudata* (Ashmead) attacks galls on lantana within a few meters of *Bidens cosmoides* in Kokee. Species of tephritid that can support parasitoid development, such as *Eutreta xanthochaeta*, serve as a reservoir for parasitoids, and allow for selection among parasitoids for ovipositing in galls. *Diachasmimorpha longicaudata* now parasitizes more than 30% of lantana galls in the Kokee area and appears to have evolved a gall-adapted race since being released for control of pest fruit flies (T. Duan, pers. comm., 1996). If these or other introduced parasitoids with limited host ranges remain in and exploit stands with many galls, then even the large, healthy populations of *Phaeogramma* will be jeopardized. It is important to note that a parasitoid does not have to succesfully develop in a fly larva to cause mortality. Even probing and oviposition by the adult female wasp can result in death to the fly larva (T. Duan, pers. comm., 1996). In recent field trials, caged *D. longicaudata* wasps were observed to probe into *Phaeogramma* galls (A. Asquith pers. comm., 1996). Thus, inundative releases of these wasps or introductions of new species pose potential threats to *Phaeogramma*.

D. <u>The inadequacy of existing regulatory mechanisms</u>.

No current protection.

E. <u>Other natural or manmade factors affecting its continued existence</u>.

Alien parasitic wasps pose a threat to the gall flies, and some alien species are purposefully introduced by Federal and State agencies for biological control of pests flies. Federal regulations for controlling the introduction of biocontrol agents are inadequate (Lockwood 1993). The U.S. Environmental Protection Agency (EPA) under the authority of the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), regulates biological control agents as pesticides. However, EPA only regulates microorganisms (bacteria, fungi, protozoa and viruses). EPA has exempted all other organisms from requirements of FIFRA because it has determined that they are adequately regulated by the U.S. Department of Agriculture's Animal and Plant Health Inspection Service (USDA-APHIS).

Although the State of Hawaii requires that new introductions be reviewed by special committees before release (HRS Chapt. 150A), post-release biology and host range cannot be predicted from laboratory studies (Gonzalez and Gilstrap 1992; Roderick 1992) and the purposeful release or augmentation of any dipteran predator or parasitoid is a potential threat to gall flies.

BRIEF SUMMARY OF REASONS FOR REMOVAL OR LISTING PRIORITY CHANGE:

FOR RECYCLED PETITIONS:

a. Is listing still warranted? ___

b. To date, has publication of a proposal to list been precluded by other higher priority listing actions? ___

c. Is a proposal to list the species as threatened or endangered in preparation? ___

d. If the answer to c. above is no, provide an explanation of why the action is still precluded.

LAND OWNERSHIP (Estimate proportion Federal/state/local government/private, identify non-private owners): This species occurs on State and private lands.

PRELISTING (Describe status of conservation agreements or other conservation activities): None

REFERENCES (Identify primary sources of information (e.g., status reports, petitions, journal publications, unpublished data from species experts) using formal citation format):

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LISTING PRIORITY (place * after number)

THREAT			
Magnitude	Immediacy	Taxonomy	Priority
High	Imminent	Monotypic genus	1
		Species	2
		Subspecies/population	3
	Non-imminent	Monotypic genus	4
		Species	5*
		Subspecies/population	6
Moderate to Low	Imminent	Monotypic genus	7
		Species	8
		Subspecies/population	9
	Non-imminent	Monotypic genus	10
		Species	11
		Subspecies/population	12

APPROVAL/CONCURRENCE: Lead Regions must obtain written concurrence from all other Regions within the range of the species before recommending changes to the candidate list, including listing priority changes; the Regional Director must approve all such recommendations. The Director must concur on all additions of species to the candidate list, removal of candidates, and listing priority changes.

Approve: ___Don Weathers_______________ ___April 2, 2002___
Acting Regional Director, Fish and Wildlife Service Date

Concur: ______________________ __________
Director, Fish and Wildlife Service Date

Do not concur:______________________ __________
Director, Fish and Wildlife Service Date

Director's Remarks: ____

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Date of annual review:__2/02_____
Conducted by:______

Comments: ____

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(rev. 1/02)